NAVAL BASE PHILADELPHIA-PHILADELPHIA
NAVAL SHIPYARD, LIFT BRIDGE
(Naval Base Philadelphia-Philadelphia
Naval Shipyard, Structure No. 915)
Mouth of the Reserve Basin
League Island
Philadelphia
Philadelphia County
Pennsylvania

HAER No. PA-387-AC

HAER
PA
51-PHILA,
709AC-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, Pennsylvania 19106

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NAVAL BASE PHILADELPHIA-PHILADELPHIA NAVAL SHIPYARD, LIFT BRIDGE

(Naval Base Philadelphia-Philadelphia Naval Shipyard, Structure No. 915) **HAER No. PA-387-AC**

Location: Located in the Philadelphia Naval Shipyard, at the mouth of the Reserve Basin, Naval Base Philadelphia-Philadelphia Naval Shipyard, on League Island, Philadelphia, Philadelphia County, Pennsylvania.

USGS Philadelphia, PA Quadrangle
Universal Transverse Mercator Coordinates
18.4415960.474085

Date of Construction: 1941-43

Engineer: Hardesty & Waddell, New York, New York

Present Owner: US Navy, Naval Inactive Ships Maintenance Facility, Philadelphia, Pennsylvania

Present Use: This structure is currently in active use as a lift bridge.

Significance: Planned as part of the pre-World War II enlargement of the shipyard in support of a two-ocean navy, the Lift Bridge was built to provide direct vehicular and rail access to the western portion of the Navy Yard. As part of a western access route to the base, the Lift Bridge helped to reduce wartime traffic congestion at the main gate on Broad Street. It is significant as a key element of the infrastructure improvements made during the pre-World War II build-up at the Navy Yard.

Project Information Statement: The Lift Bridge is proposed for major alterations to permit larger ships to enter the Reserve Basin. The height of the support towers is to be increased so that the lift span can be raised above battleship and aircraft carrier superstructures. To mitigate the adverse effect of the proposed alterations, the PA SHPO stipulated documentation of the structure.

Project Historian: Steven Bedford, Ph.D., Fitzgerald & Halliday Inc., for TAMS Consultants, Inc., 655 Third Avenue New York, NY, 10017

Summary Description of the Lift Bridge

The Lift Bridge is located at the mouth of the Reserve Basin, just west of the channel opening that connects the Basin to the Schuylkill River. The overall length of the bridge is 400'. It consists of a central lift span flanked by two, 208'-high elevator towers with dual lifting motors located in each machinery room. The lift span is a 240'-long steel Warren truss with a segmental top chord. It can be lifted to provide 135' vertical clearance (at mean high water, or MHW) with a clear channel opening, between fenders, of 200'. Seven-foot-wide walkways cantilever from both sides of the bridge. The entire bridge is made up almost entirely of steel plate riveted together to form structural sections. Electrical cables connecting the towers are draped along each tower and the lift span. The depth of the water below the bridge was initially dredged to 25' below MHW, while electrical cables associated with the operation of the bridge cross the channel in a trench approximately 30' below MHW.

The Bridge Foundations

The bridge towers are each supported by a pair of concrete foundations that rest on wood pilings of varying depths, while relieving platforms, massive concrete pads that help to counter balance any overturning moments created during bridge operations, flank the north and south portals of the bridge. The northern pad is 40' x 60' x 15', while the southern pad is 40' x 100' x 10'. The foundations for each tower are approximately 75' apart, on-centers, separated by shallow open water. The 25' thick rectangular, spread footings of the inboard foundations project approximately 90' from retaining wall into the channel and extend to a depth of approximately 50' below the bridge deck. The inboard foundations rise from their footings in the shape of a 60' x 15' oval. The outboard foundations, located on more solid ground, go to a depth of approximately 40' below the bridge deck, and the footings are only 15' thick. Battered piers rise to approximately 20' above the footing to support the outer end of each tower. Each tower foundation is protected with wooden fenders placed on the channel side of each pier.

The Elevator Towers

The elevator towers are connected to the bridge foundations by means of pin connections at each of the towers' four columns. Each tower is approximately 70' x 45'. The east and west elevations of each elevator tower consist of Pratt trusses with a sloping chord extending at the base of the tower to provide additional support. The north and south faces of each tower (facing the lift span) consist of K-and Warren trusses with knee brace connections at each bridge portal. The lift span is built in the form of a Warren truss. The structural system limits clearance on the bridge to 22' at the center of the portal and 15' at the deck curb. The four columns of each tower consist of box beam supports built up from riveted steel plates. Each diagonal is built up from plate sections that are connected with riveted diagonal strapping. An auxiliary counterweight runs up and down in each inboard column, connected to the center of the lift span lifting girder by cables running over auxiliary sheaves located on each inboard tower leg, approximately 110' above the bridge deck. A slot in the inboard columns serve as guide tracks for the main counterweights.

At the deck level, a counter weighted metal guardrail runs up and down a guide created by a slot in the second vertical element of each tower. The motor and drive shafts to operate the guardrails are located on a horizontal truss placed just behind the portal truss. The roadway deck beneath each tower is concrete with an asphalt wearing course. Train tracks run in the center of the deck. The deck is supported by plate girders that connect to the four tower columns. Additional support for train loads is provided by a pair of plate girders placed longitudinally beneath the rail locations.

Control and Machinery Rooms

Access to the towers and machinery rooms is provided by stairs on the north side of each tower. In the north tower, these stairs provide access to a small companionway at the top of the lift span truss. A small elevator and caged, inclined ladders provide access to the machinery room approximately 190' above the bridge deck. Access to the outside of the machinery rooms is provided by vertical ladders on the western side of each tower.

The stairs on the south tower provide access to the control room, a steel, box-like structure which is suspended approximately 15' above the bridge deck. The control room is 25' x 15', with windows wrapping around the north, south, and west elevations. The control console for the bridge is located in the north end of this room, with windows providing full visibility of water and road traffic.

Above and perpendicular to the control room is the electrical equipment room. Constructed in the same manner as the control room, the approximately 38' x 18'-structure by is reached by an enclosed stair on the eastern side of the control room. Aside from housing the electrical relays, transformers and circuit breakers for the bridge, the area also contains a toilet and sink. An exterior deck provides access to a small elevator and caged inclined ladder that, in turn, provides access to a small open-grate steel platform, approximately 180' above the bridge deck. Just above this small upper deck is the south tower machinery room, which is reached by an open-grate stair. Located approximately 190' above the ground, the north and south tower machinery rooms are mirror images of one another. Currently, only the south tower is readily accessible because the north tower elevator is not operational. Each machinery room is clad in a curving sheet-metal structure with small square windows on all sides. The cladding is bolted to a frame whose connections are protected by battens. Curved projections at either side of the inboard wall of the machinery rooms protect the counterweight sheaves, which project out from the machinery rooms to pick up the main lifting cables. A central panel of the inboard wall is removable to permit hoisting access. The interior of the machinery room is faced in gypsum-cement board and the floor is concrete. A 3-ton-capacity crane rail runs along the ceiling of each machinery room. On the outboard wall of each machinery room is the machinery for the passenger elevator below. In the center of the rooms are the paired electric drive motors, emergency back-up motors, gearing and brakes, as well as the sheave drive shafts. Hoisting sheaves are on the inboard sides (east and west) of the machinery rooms. Each sheave is a single steel casting, 14' in diameter, with steel teeth bolted to one side. The sheaves each carry 14 wire-rope hoisting cables, which continue down though the machinery room floor and connect to the main counterweight in each tower.

The lifting machinery consists of two synchronous 125 horsepower electric motors attached by flexible couplings to an 8"-diameter geared shaft. This geared shaft is then connected to the approximately 5'-diameter driven spur gear of the main clutch assembly. The motive force from the spur gear is transferred by a pair of bevel pinion gears meshed with 4' diameter-equalizing bevel gears attached to 6"-diameter shafts resting on simple bearings. This main clutch shafting is connected to 4"-diameter shafts by floating shaft couplings. These shafts, extending virtually the entire length of the machinery room, in turn, drive 6"-diameter pinion gears on each end. These pinion gears connect to large diameter (approximately 5') spur gears that transfer the motive force to short (approximately 3' long, 8" diameter) geared shafts that mesh with the gearing on each hoisting sheave. Seventy-five horsepower emergency motors are connected to the system by means of an idler spur gear on the main motor shafting. Brakes are located on each motor shaft and each drive shaft.

Each main counterweight consists primarily of a steel box almost completely filled with poured concrete. The remaining area inside the counterweight contains movable concrete blocks which were used for final balancing of the lift span. The inboard face of each counterweight is provided with guides which engage slot tracks on the tower columns.

The Lift Span

The lift span is an eight-panel, Warren- thru truss with a slightly arched segmental top chord. Each panel is approximately 30' long on centers, and the heights vary from 40-45', with 22' minimum clearance in the center of the roadway. The truss web is made up of riveted plate material. The vertical elements are solid I-sections, while the diagonal elements consist of diagonal steel strapping. All connections between the truss chords are reinforced with riveted gusset plates. The top lateral bracing consists of a K-truss system. The lift span deck (approximately 40' wide) has an open-grid steel surface supported by lateral I-section deck purlins. The purlins rest on steel I-section stringers (six to a panel bay, approximately 3' on centers) that frame into built-up plate girders serving as floor beams. Approximately 5' deep, built-up H-section stringers run the length of the span beneath the railroad tracks, while deeper (7') built-up box beams form the lower chord of each truss. Lateral bracing for the deck is provided by steel I-sections in an X pattern, connected to the floor beams by means of riveted gusset plates. The two sidewalks cantilever from the bottom chord of the truss, supported by brackets projecting every 30' from each floor beam.

The top chord of each portal frame of the lift span consists of a built-up steel lifting girders (approximately 3' deep). The lift cables are connected to both sides of each girder, bolted to a separate steel plate that locks into the lower flange of the girder. In the center of each lifting girder is a secondary cable connection linked to the auxiliary counterweights. When lowered in place, the southern end of the lift span has fixed connections consisting of a semi-circular, pin-connected seat. In addition, projections from the deck of each tower help seat the lift span in position. The northern end of the lift span rests on a roller mechanism, permitting expansion.

Locking mechanisms are located at each end of the lift span. They are hydraulically powered bars which insert into slotted projections extending below the end-floor beams. Additional projections from the end-floor beams house height and skew gauges. Roller guides are attached at the eight outside corners of the lift span. They roll up and down the exterior of the tower columns. Beneath the guides and the lift cable attachments are pans to catch grease. Since the bridge is in the flight path of Philadelphia International Airport, the tops of each tower and the center of the lift span are illuminated with blinking red warning lights.

Operation

The operation of the lift bridge is quite simple. From a console in the control room, the operator turns on the motors, lowers the outsides gates, releases the locking mechanisms, and then engages the four synchronous electric motors. Controls on the panel indicate the height of the bridge and its rate of ascent. As the lift span reaches its upper limits, the auxiliary counterweights add their load to the lift span side of the sheave, helping to counteract the imbalance created by having the weight of the cables all on one side of the sheave. The process for lowering the span is simply the reverse of raising the bridge, with the exception that, in order to seat the bridge without any skew or height differential at either end, the operator may have to raise and lower the bridge several times, adjusting all four motors to ensure that the lift span seats properly.

Historical Background

The genesis of the Lift Bridge lies in the US Navy's planning process just before the United States' entrance into World War II. When the 20 percent fleet expansion was authorized in 1938, the primary construction and repair facilities at Philadelphia Naval Shipyard (PNSY) were one large and two smaller dry docks, two battleship building ways, and one smaller shipway. Construction and repair facilities did not exist west of the battleship ways at Seventh Street West and Shipway No 3. The western portion of the yard was swampy and undeveloped. By 1938, PNSY had been established as one of three battleship building yards on the east coast (the two others were the Brooklyn Navy Yard and Norfolk Naval Shipyard) and construction work at the shipyard then focused on improving the existing facilities at the yard so that the latest class of battleships (the *Iowa* Class) could be constructed on the existing shipways.[1]

Even before these improvements were authorized in 1938, the Navy's ship design branch, the Bureau of Construction and Repair (BuCR), had just completed the design of the *Iowa* class ships and was mindful of the stabilizing advantages of a wider beam battleship. As a result, BuCR began to agitate for widening the locks on the Panama Canal (the limiting factor in US Navy ship design) and press for wider graving docks at Navy shipyards. By mid-1939, BuCR began to develop a more heavily armored battleship than the *Iowa* class, whose displacement would exceed 55,000 tons. Given this increased weight and size, it was decided that this new class of ship be built in dry docks, minimizing the potential for damage that such a massive hull might receive as it descended down a traditional shipway. Apparently in concert with BuCR, the US Navy Bureau of Yards and Docks (BuDocks) was planning to build dry docks and support facilities at PNSY and the Norfolk Naval Shipyard for the construction of this latest class of battleship. At PNSY, the new shipbuilding area would be placed on the western side of League Island, the only undeveloped land close to the existing shipbuilding facilities.[2]

The need for new facilities at Philadelphia was made more pressing when, in February 1940, the Secretary of War agreed to order a new set of 140' wide Panama Canal Locks. At the same time,

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[1]United States Bureau of Yards and Docks, *Building the Navy's Bases in World War II.* (Washington, D.C.: GPO, 1947): p. 185.

[2]Ibid.; Norman Freidman, *U.S. Battleships* (Annapolis, Maryland, 1985): pp. 331-333; Luce, Ehrman, and Landwehr,. "Historical Narrative, Public Works Division." 1946, Unpublished manuscript, Office of Naval History, Washington, D.C.: p. 90.

the Secretary of the Navy removed the previous limit on battleship beams. This meant that all new dry dock and graving yard construction would need to be built to new, much larger, standards.[3]

In order to support these new facilities at PNSY, almost doubling the industrial capacity at the yard, it was necessary to plan additional access to the shipyard, whose one entrance on Broad Street would be overwhelmed by a dramatic increase in traffic. Consequently, a second entrance was planned at the western side of the base. In order to reach the western end of League Island, the Reserve Basin would have to be bridged, and a four-lane rail and highway bridge was consequently planned at the mouth of the Reserve Basin, in direct line with the proposed location of the new dry docks.[4]

After the invasion of Denmark and Norway in the spring of 1940, followed by the invasion of the Low Countries and the fall of France on June 22, 1940, Congress responded by increasing naval appropriations. Having just authorized an 11-percent increase on June 14, 1940, Congress called for the creation of a "two-ocean" navy involving a 70-percent increase above previously authorized levels. The enabling legislation for this action, the *First Supplemental National Defense Act of 1941* (HR 10055, 76th Congress, 3rd session), was passed on June 26, 1940. The act specifically appropriated ten million dollars to begin construction of new shipbuilding facilities at PNSY. On July 1, 1940, BuDocks authorized Contract No. NOy 4100 for the development of the western side of League Island. The entire project included the construction of two new shipbuilding dry docks, two marine railways, large fabrication buildings, a series of piers and sea walls, and a lift bridge. The dry docks were to be among the largest in the world, and were intended to be used for the construction of the first two newly designed, wide beam, super battle-ships of the *Montana* Class, the *Montana* and the *Ohio*. Marine railways were to be used for submarine and small ship construction repair and overhaul.[5]

The design of this complex was assigned to two New York-based consulting engineering firms--Frederick R. Harris and Waddell & Hardesty--on a cost plus fixed-fee basis. Waddell & Hardesty were primarily responsible for the design of the craneways, jib cranes, and the Lift Bridge over the Reserve Basin. Initially the bridge was planned to accommodate four lanes of traffic and one railway track. However, probably in light of wartime material shortages, the size of the bridge was reduced to two traffic lanes and a central railway track. The use of a lift span, as opposed to a

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[3]Ibid.

[4]Luce etal.: p. 92.

[5]Ibid: pp. 88-92.

swing or bascule span, was a logical choice for it created the least possible horizontal impediment to navigation, and could be raised to sufficient height to clear the superstructure and mast of any US Navy ship that drew less than 25' of water (destroyers and some cruisers), the depth of the Reserve Basin.[6]

The initial design of the bridge was completed in August 1941, with minor revisions (e.g. adding windows in the machinery room) prolonging the design work until November 1941. The design of the bridge itself was advanced, but it was by no means technologically significant. Since 1935, Waddell & Hardesty had been designing bridges that employed synchronous motors coupled to the same shaft, making it possible to place all the operating machinery at or near the tower tops. This arrangement also permitted the direct application of power to the counterweight sheaves by means of gear trains, eliminating operating cables common to earlier designs. Neither the height of the span nor its length are notable. Waddell & Hardesty had previously designed a 544'-long lift span that rose 140' above sea level.[7]

While final revisions were occurring, the contract for the fabrication and erection of the bridge was awarded to Phoenix Bridge Company of Phoenixville Pennsylvania on September 16, 1941, at a cost of $1,165,500. Phoenix in turn subcontracted all but the steel fabrication and bridge erection. Electrical Contractor Phillip H. Zipp of New Brunswick, NJ was to install the electrical equipment, including trenching the channel to bury any electrical cables that had to cross the basin entry. Earle Gear & Machine of Philadelphia, PA was responsible for the installation of all operational equipment, including sheaves, shafts and ring gears. General Electric Company of New York City supplied the motors; Otis Elevator supplied the elevators; the counterweight sheaves were supplied by the Pittsburgh Steel Foundry of Glassport, PA; Central Iron and Steel Company of Harrisburg, PA supplied the 500 tons of plate steel. The steel was to be delivered beginning in December 1941, while another 211 tons of steel were to be delivered in February 1942 by Lukens Steel of Coatesville, PA.[8]

Phoenix Bridge received its notice to proceed on October 4, 1941, and, on October 11, 1941, was advised to complete work by July 31, 1942. The firm immediately began work on creating templates in anticipation of delivery of the steel plate, and apparently continued working apace until

[6] Ibid.: pp. 90-91.

[7] George Hool ed., *Movable and Long-Span Steel Bridges* (New York: McGraw-Hill, 1943): p .179.

[8] Department of the Navy, Bureau of Yards and Docks Contract Correspondance,RG 71, Box 1153, National Archives.

December 1941, when in light of the Japanese attack on Pearl Harbor, the Navy authorized all contractors to use overtime to complete their work. Phoenix responded by saying that their template shop was already working overtime, and that the fabrication shop would work overtime once sufficient steel plate was in hand.[9]

The construction work on the bridge foundations on both sides of the Reserve Basin began in January 1942, and was completed before March 23, 1942, when the erection of the steel towers was begun. The fabrication of the lift span was carried out simultaneously on cribbing laid in the Reserve Basin. Judging from correspondence in contract files, it appears that the bridge erection work was slowed by the usual problems that plague work during wartime--lack of skilled personnel and a shortage of crucial materials such as steel plate.[10]

Of course the delays in the bridge completion only served to aggravate the traffic congestion at the PNSY's main gate on Broad Street. Congestion was caused by the opening of Dry Dock No. 4 southwest of the Reserve Basin in April 1942, and the nearly 50,000 employees who used the Broad Street entrance daily. On June 9. 1942, the Commandant of the Fourth Naval District wrote the the Chief of BuDocks that: "bridge is urgently needed to facilitate movement of traffic in and out of yard and to avoid delays incident to present congestion at main entrance on Broad Street."[11]

By September 17, 1942, the towers were completed, the mechanical equipment was sufficiently in place, and the lift span was fabricated. On September 18, 1942, the lift span was floated into place by two barges, jacked into position, and attached to the lift cables. It appears to have been available for use on October 31, 1942, when connecting roads and the entrance to the bridge were completed. The bridge still lacked its final coat of paint, which it did not receive until the spring of 1943.[12]

It is not known if the completion of the Lift Bridge eliminated congestion at the main entrance PSNY, but it must have contributed to reducing the severity of congestion, and it may have helped to expedite shipbuilding because it provided direct access for men and material to Dry Docks No.4 and No. 5 located southwest of the Reserve Basin.

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[9]Ibid.

[10]Ibid.

[11]Ibid.

[12]Ibid.

The bridge remains in use today and there have been no major changes since its construction. It has, however, received minor repair to its superstructure; its emergency braking system has been overhauled; and the control panel has been modernized; the electrical cables connecting both motor rooms now hang along the west side of the bridge.

Waddell & Hardesty

The designers of the bridge, Waddell & Hardesty, were renowned creators of movable bridges. John Alexander Low Waddell (1854-1938), the founder of the firm, was an 1875 graduate of Rensselaer Polytechnic Institute, and subsequently worked as a surveyor in Canada and Missouri, before going to West Virginia to serve as coal mine engineer. In 1878, he returned to Rensselaer to teach until 1888, serving as Assistant to the Professor of Rational and Technical Mechanics. After a brief stay as Chief Engineer of an Iowa bridge building firm, Waddell left for Japan to become Professor of Civil Engineering at the Imperial University in Tokyo, where he published two books on bridge engineering and design. In 1886, Waddell returned to the United States where he became an engineer for Phoenix Bridge Company. By 1887, Waddell had opened an office in Kansas City, serving as a designer and agent for Phoenix Bridge. Acting as Phoenix's agent, Waddell secured such important commissions as an elevated railway in St. Louis, and the Red Rock Cantilever Bridge over the Colorado River between California and Arizona. In 1892, he left Phoenix Bridge and devoted himself entirely to consulting work, particularly the design of movable bridges, including several swing spans over 500' long. By 1893, Waddell, in partnership with Ira Hedrick, had designed the first substantial lift bridge, the Halstead Street Bridge in Chicago, whose 103'-span rose 140' in the air in just over one minute. Waddell then served as Consulting Engineer for the Loop Elevated Railroad in Chicago, and designed numerous long-span, movable and fixed bridges. In 1907, John Harrington took Hedrick's place and the new firm became known as Waddell & Harrington, and then, in 1915, Waddell & Son. By 1920, Waddell had moved his office to New York and had designed hundreds of bridges throughout the United States. By 1928, Waddell had designed over fifteen major lift bridges with over 300'-long spans, as well as over fifty lift bridges with lesser spans.[13]

Shortridge Hardesty (1884-1956) joined the firm of Waddell & Harrington in 1908, just after his graduation from Rensselaer Polytechnic Institute. He became designing engineer of Waddell & Son in 1916, and four years later moved to New York City with Waddell. In 1927, Hardesty became Waddell's partner in Waddell & Hardesty. After Waddell's death in 1938, Hardesty continued the

[13] A full biography of Waddell can be found in Frank Skinner ed., *Memoirs and Addresses of Two Decades by Dr. J.A.L. Waddell* (New York; 1928): pp. 8-15.

firm's engineering practice. In 1945, he formed the partnership of Hardesty & Hanover with Clinton D. Hanover Jr. As chief design engineer, and later, partner of his own firm, Hardesty, an extremely energetic man whose son called him the "world's first workaholic," oversaw the design of virtually all bridge projects produced by Waddell & Hardesty and Hardesty & Hanover from 1920-1956, including over 130 bridges. Hardesty's bridge-design work included: the Goethals and Outerbridge cantilever spans across the Arthur Kill (1928) in New York; a cantilever bridge over the Mississippi in Cairo, IL (1929); lift bridges over the Hudson River at Albany and Troy, NY (1933); the South Grand Island Bridge over the Niagara River (1933); the Cape Cod Canal Railroad Bridge (1935); the Rainbow Bridge over Niagara Falls (1944); and the New York Central Lift Bridge over the Harlem River in NY (1956). The firm of Hardesty & Hanover continues to this day.[14]

Phoenix Bridge Company

During the nineteenth and early twentieth centuries, the Phoenix Bridge Company was a prominent bridge building companies in the United States. The Phoenix Iron Company, parent company to Phoenix Bridge, had been in existence since 1790, first as a nail factory, and later, as an early producer of anthracite iron and a distinct innovator in the production of rails. With the introduction of structural shape rolling in 1855, Phoenix Iron Company entered the field of bridge construction. In 1862, Samuel Reeves, the owner of Phoenix Iron, had received a patent for the creation of the Phoenix column, a hollow, wrought-iron column built up from curving rolled sections. It proved to be superior to its cast iron counterparts, especially when used as a compression member in iron truss bridges. To exploit the use of wrought iron in bridges, in 1864, the iron company organized the Kellogg, Clarke Company which became the bridge building arm of Phoenix Iron. Under the design leadership of German-born engineer Adolphus Bonzano, the bridge company flourished.

In 1871 the firm was reorganized as Clarke, Reeves, with Thomas A Clarke, a noted bridge builder, as president. In the 1870s, the Phoenix Iron Company became the largest producer of structural shapes in America, and Clarke, Reeves became one of the first bridge companies in the country to file patents on a variety of bridge designs and publish these designs in a catalogue. Customers would study the catalogues, and choose the most suitable design, which would be "custom tailored" and prefabricated in Phoenixville, PA.

[14] "Shortridge Hardesty Dies at 72," *New York Times*, October 18, 1956; Telephone interview with Egbert Hardesty, son of Shortridge Hardesty, November 22, 1998.

In the 1880s, when the mill began to roll structural steel, Clarke, Reeves reorganized to become Phoenix Bridge Company under the leadership of members of the Reeves family. In 1889 the company manufactured its first steel bridges.

Phoenix Bridge then developed a nationwide system of engineers who served as designers and sales agents. Consequently their business grew dramatically, particularly in the area of railroad bridges, highway bridges, long-span truss bridges and moveable bridges of all kinds. However, the notorious failure of the Quebec bridge in 1907 nearly brought the company down. The company did manage to survive, however, building such notable structures as the Manhattan Bridge in NY (1909-10).

By the mid-1920s, reacting to increased competition from such massive conglomerates as American Bridge Company, Phoenix Bridge became an all-purpose structural steel construction business. However, they did still build numerous lift bridges, many of which were designed by Waddell & Hardesty, including the Cape Cod Canal Bridge with a 544'-span capable of rising 140' above the sea. During World War II the company also turned to ship and dock construction to survive. After the war, the company slowly shrank in size until its closure in 1962, having produced over 4, 200 bridges during the course of its existence.[15]

Significance

Although not technologically distinguished, the Lift Bridge served an essential function as part of the western development of PNSY just prior to and during World War II. Planned as part of the pre-World WarII enlargement of the shipyard in support a two-ocean navy, the Lift Bridge was built to provide direct vehicular and rail access to the western portion of the Navy Yard. As part of a western access route to the base, the Lift Bridge helped to reduce wartime traffic congestion at the main gate on Broad Street. It is significant as a key element of the infrastructure improvements made during the pre-World War II era at the Navy Yard.

[15]The full history of the Phoenix Bridge company can be found in Thomas Winpenny, *Without Fitting Filing, or Chipping, A History of the Phoenix Bridge Company* (Easton, PA: Canal History and Technology Press, 1996): passim.

Sources of Information/Bibliography

A. Engineering Drawings

Existing condition drawings and details of the Bridge are available through the Caretaker Site Office, (Former) Naval Base Philadelphia B Philadelphia Naval Shipyard.

B. Historic Views

Historic views of the Shipyard were recently given to the Mid-Atlantic Regional Office of the National Archives and were unavailable for consultation because they were not yet catalogued. Numerous views of the Lift Bridge are available from Record Group 71, National Archives.

C. Interviews

Egbert Hardesty, son of Shortridge Hardesty and a retired partner in Hardesty & Hanover, telephone interview, November 22, 1997.

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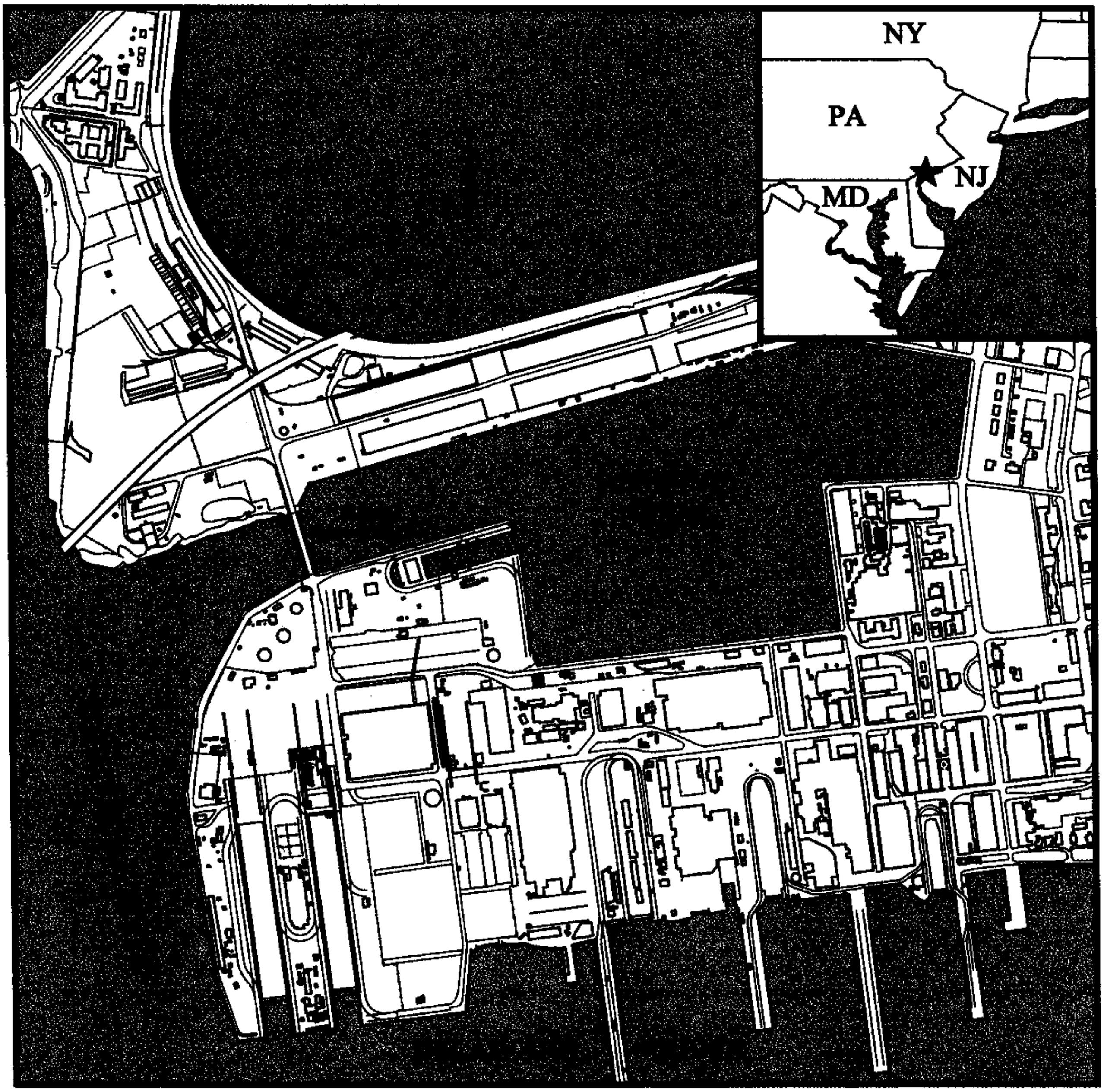

Source: Aerial Data Reduction Associates, Inc., February 7, 1995. On file at TAMS Consultants, Inc., New York, NY.